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THE POSITIVE IMPACTS OF USING DATA VISUALIZATION TO MONITOR ONLINE EXAMS IN GEOGRAPHY EDUCATION

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ABSTRACT

Online tests and classes are becoming widely adopted systems in academic institutions. This is quite a recent phenomenon whereby I have had the opportunity to experience the transition of using these online systems in geography classes. From teaching in a traditional classroom setting to using online systems such as ETUDES at the community college level (teaching at two community colleges in the Los Angeles Community College District) or CLE (teaching classes at UCLA) for hybrid as well as online classes within a matter of a couple of years, I have been able to witness the advantages and disadvantages of both systems. Online classes and exams are becoming a prevailing practice in education. Because they are being used more widely, it is imperative to assess student learning behavior based on how they perform on varying test structures in order to improve the system of testing.

I discuss the positive effects of using data visualization and specific techniques I used to detect patterns of learning behavior for students taking in-class and online exams.

Keywords: exam, Internet, systems, pattern, data visualization

INTRODUCTION: WHAT DATA VISUALIZATION IS AND HOW IT IS USED

Information visualization is enhancing and improving the human capability to detect patterns and relationships between data sets while exploring and analyzing data (Alexandru Telea, 2008).Geography technology such as geovisualization allows users to visualize and analyze previously unknown relationships and patterns with new methods (Shin, 2006; Wiegand, 2001).

In the context of geography technology in education, Artvinli (2009) emphasizes how new approaches allow educators to go beyond basic knowledge and present new levels of comprehension.

Although data visualization charts have allowed me to detect several previously unknown test strategies used in geography classes and several correlations among questions, which gave useful feedbacks on the test quality, I was able to improve the affect of these data visualization charts by not only using more data, but also by enhancing data visualization and using new and different data visualization techniques.

I have been teaching physical geography for a number of years and some of the most significant exercises and components of the class have been GPS and GIS. Students not only enjoy activities related to GPS and GIS but they also find these exercises beneficial. They have the opportunity to familiarize themselves with new technologies while simultaneously learning more about geography. Scholars such as Karmen Kolenc-Kolnik support the use of GIS by geography instructors in order to stimulate knowledge of geography and to enable the development of “inter-subject connection” for further use and potential preparation for young students’

professions (Kolenc-Kolnik, 2006, 1). Therefore using the web (i.e. ESRI exercises) and new technology "in the classroom is not a replacement for other kinds of research, but it is a valid way to enhance student learning and excitement about geography" (Logan et al, 2010, 20). Because technologies such as GIS, GPS, and remote sensing are becoming so prevalent in geography, assessing student learning behavior in taking online exams in geography education is especially important. In my specific study, the students who are the subjects of my investigation had some prior experience using GIS and geography technologies in general. Does this mean that the transition from in-class to online tests is easier for them as opposed to students without this prior experience? Data visualization can show such patterns. Through using data visualization, I show how to analyze the results of in-class and online examination and therefore, how it affects geography education and learning behavior at large.

RESEARCH METHODOLOGY: TYPES OF DATA VISUALIZATION AND HOW IT IS DEVELOPED

As data visualization and associated analysis tools have become more accessible in recent times, geographers have dedicated more attention to exploring their uses in enhancing geographic education (Board on Earth Sciences and Resources, National Research Council 2006; Baker 2005; Bednarz 2004; Kerski 2003; Meyer *et al.* 1999).

My research methodology includes quantitative analysis namely data visualization to detect patterns by analyzing students' test scores. In many related studies pertaining to the use of technology in classrooms, the research methodology used by scholars has been more qualitative. For example, in "The Digital Versatile Disc as a Learning Support Medium in the Teaching and Learning of Map Work", Aubrey Golightly uses qualitative analysis techniques including observation, interviews with the learners, and questionnaires for her research methodology.

In articles about geography technology in education that do use data visualization, the purpose of using geo/datavisualization is to convey information to the readers in an effective way rather than to use the data visualization for the authors'/instructors' own purposes. In an article relating to online courses, WinklerPrins et al, use pie graphs and bar graphs to show the results of their study in evaluating their students.

Scholars who have conducted studies on teaching geography technology who support data visualization as a research methodology include Martin Raubal, Bernhard Gaupmann, and Werner Kuhn (1997) who not only support instructors learning from using data visualization but also "students [in order] to perform and visualize operations as well as to see how the data are processed" (1). Therefore, I have been sharing my study and results with my students which are learning from the process as well.

In "E-learning for Geography's Teaching and Learning Spaces" Lynch et al "promote the idea that considering best practice with reference to educational technology will increase the versatility of teaching geography in higher education" (2008, 1). As a result, through using data visualization as the instructor, to detect technology-use patterns (namely online exams) in the classroom, I learn the best ways to apply and improve student use of technology in the classroom. Lynch et al emphasize the strategies and techniques employed by the "teacher" which are then transferred to the "learner". Clark (1994) also emphasizes the method used by the instructor as the "active ingredient" (26). Lynch et al use data visualization to show e-learning trends (Figure 1, 2008, 2). They state that "one of our purposes is to encourage geography faculty to assess where any teaching-learning activity is placed in e-learning 'space', consider whether it could be re-located, and establish the most effective way to get there" (2008, 2). As a result, Lynch et al would support my research methodology which is an "e-learning space" in and of itself that assesses another e-learning endeavor, online examination.

The sample group of my research consists of 55 students taking Geography 1, Physical Geography as a GE requirement at West Los Angeles College and Los Angeles Pierce College.

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Out of the three main dimensions of spatial thinking: Spatial-visual stimulus, spatial orientation, and spatial mutual relations (Gollede & Stimson, 1997 cited in Bednarz, 2001), I focus on spatial-visual stimulus, using data to show spatial patterns visually. Two of the main stages of spatial thinking discussed by Artvinli (2009, 5) developed in geography education (Bednarz, 2001) which I use most are "Abilities (skills) that recognize spatial distribution and spatial patterns and Associating and correlating spatially distributed phenomena."

I use two different sets of data to compare and contrast student learning behavior based on the type of test (online vs. in-class). Two online test data sets are used with two data sets for in-class tests. Data visualization is the perfect tool to allow geography instructors to analyze student performance data and subsequently improve the assessment process. The types of models I use are common to show statistical information that measures relationships and their correlations (McMillan & Schumacher, 2006). Although several geographers have sought to examine and analyze the pluses and minuses of incorporating technology into courses (Smith et al., 2006; Fletcher et al, 2007) most scholars and instructors have not used technology themselves to assess the impacts of using new technology in courses. I will discuss other research methodologies and how they compare to mine in the "Results" section.

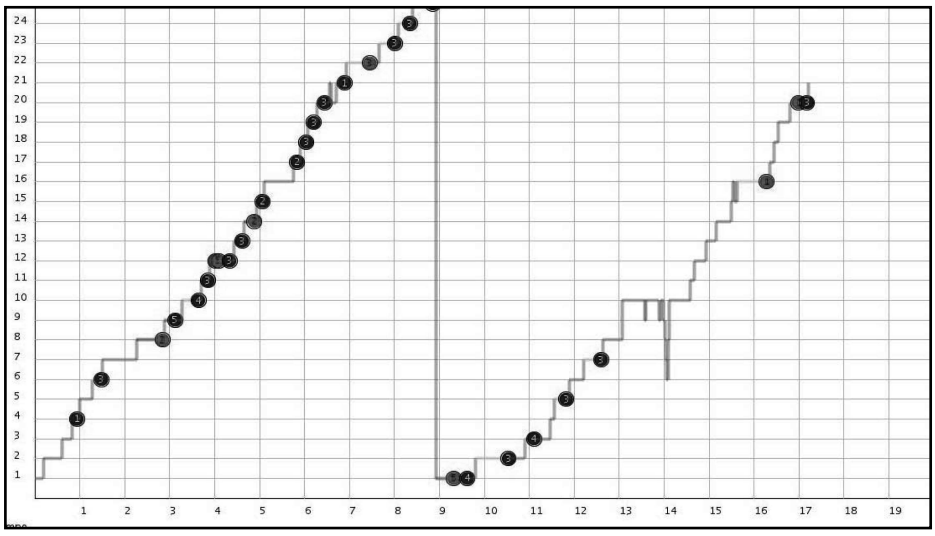
I use a 'chronological reviews of tests' and compare online tests with each other rather than comparing online with in-class assessments. Although I do evaluate the differences between the first online tests given as compared to the second, the aim of my study is to compare the online to the in-class exam scores.

Furthermore, in terms of the actual visualization methods, I use geometric and symbolic methods (i.e. represented by using lines). Symbolic visualization is used for representing non-numeric data (i.e. demonstrated through pixels, icons, etc).

Discussion: Significance of Experimentation

Although there are technical differences (examples of 2D and 3D displays that I use are line graphs, histograms, box plots, and scatter plots), my data visualization emphasizes the students' scores in addition to variables such as time. The first data visualization is a 2D chart showing a chronological review of tests taken by the students:

Table 1
Chronological Display of Exams



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The two axes show the time line (horizontal axis) and the questions submitted to the learner (vertical axis), respectively. Therefore, everything is in the context of time. The horizontal line segments show the view of an item for a given time interval.

The basic elements used in displaying a chart are:

Figure 1: *The four basic elements in displaying a data visualization chart.*

However, for my data visualization I did not decide to use circles (i.e. in the form of pie charts, etc). This is because different forms of visualization are better for different purposes. For example, circles are better for more specific purposes. Circles can represent the responses given by students on specific items. This is demonstrated through the example of a pie graph that displays specific strategy usage. Because my uses of visualization methods are for data that is more general, circles (i.e. in the form of pie charts) are less useful.

Therefore, instead of the pie chart, I found a box plot much more useful for my specific type of data:

Table 2
Sample Box plot of student scores

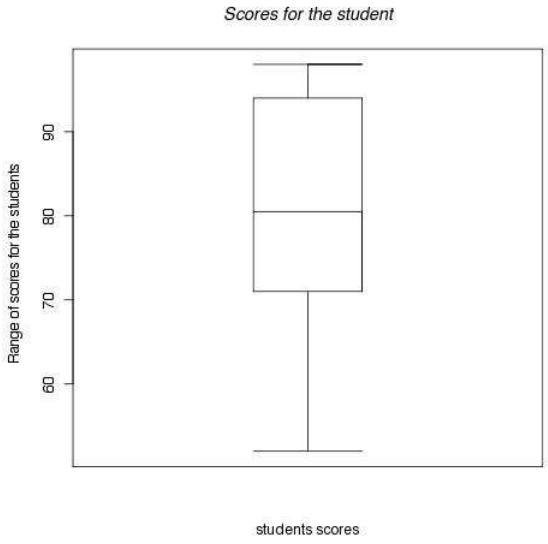
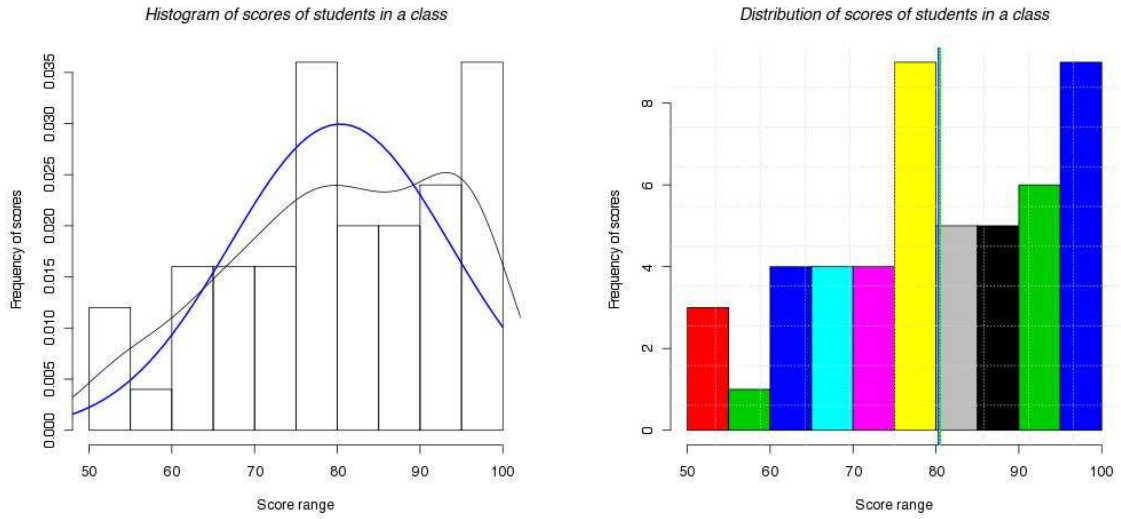


Table 3 and 4
Bar graph and histogram of student scores



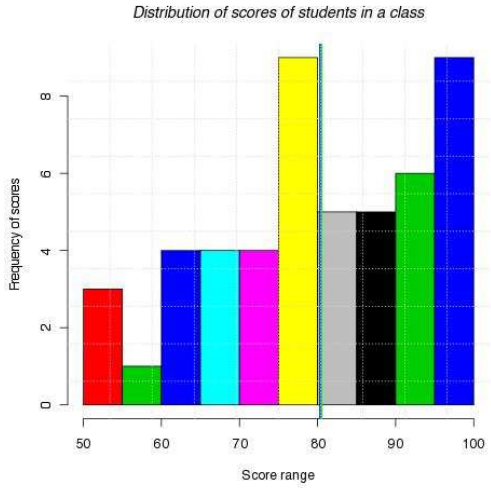
The bar graph and histogram show more detailed outcomes than the box plot.

My Data Visualization

I decided to use a simple bar graph to introduce the data and have a fundamental visual of the scores. This helps to have a general understanding and idea of how students are performing.

In-Class Tests:

Table 5
Bar graph of in-class student scores

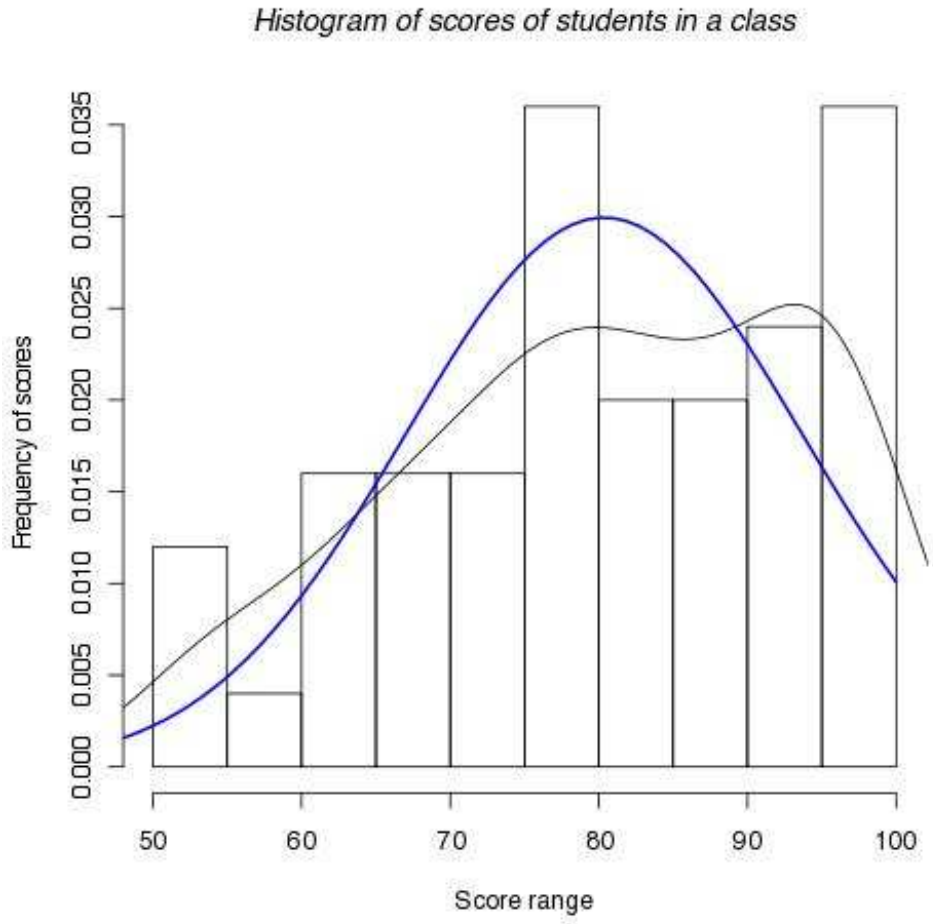


This graph displays the distribution of scores for students taking in-class exams. I expected this outcome; however I was surprised to see the mean and the median have a close result. This graph was a good choice for creating my first data visualization for students' scores because it gives a general idea of (in-class) student performance.

The next data visualization I decided to use is a histogram using the same variable(s) (student in-class exam scores) in order to compare both methods. Which one is more effective?

Although the bar graph is more visually pleasing, the histogram is easier to read. Immediately, one notices that it follows the conventional pattern (normal weight distribution model). The score range once again appears to be average, as expected.

Table 6
Histogram of in-class student scores.



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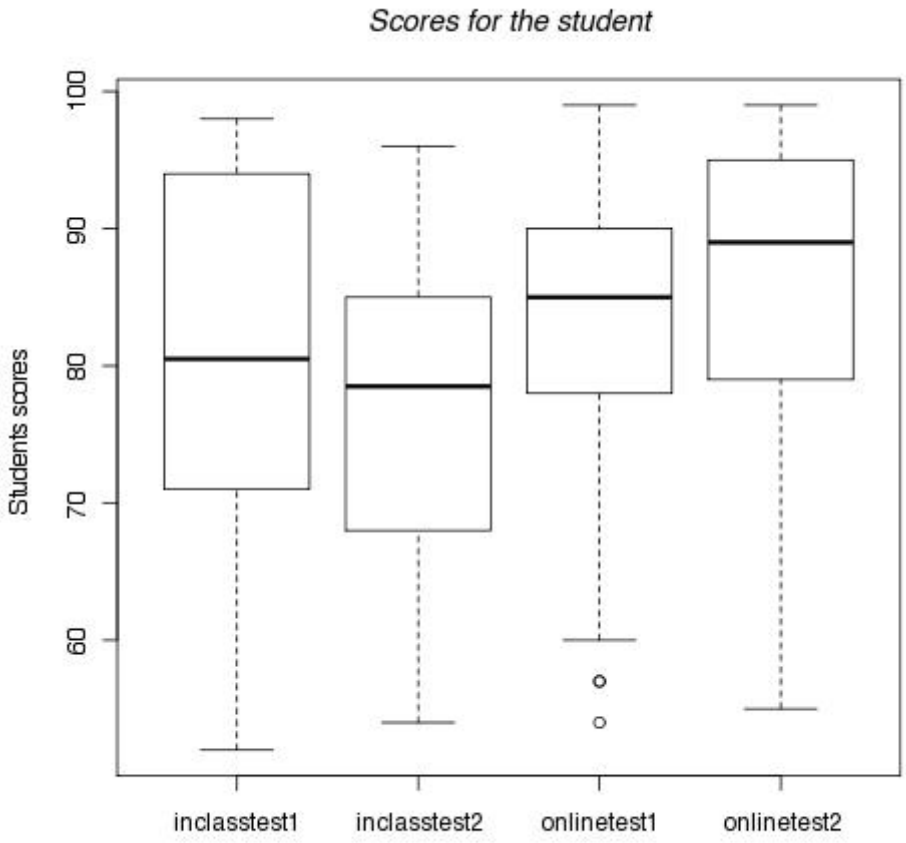
Comparing In-Class to Online Assessments

The box plot was one of the most effective ways for showing the comparison of online exam scores to in-class scores. It is clear and easy to read. One can immediately see as well as compare the averages and spot the 'outliers' (students who scored the lowest).

Table 7
Box plot of student scores



The last data visualization I used that I found most helpful for comparing online and in-class exam scores is line graphs. The lines graphs I created turned out to be both visually aesthetic as well as the most effective. This type of data visualization shows the most detailed information making it the best way to analyze the data. Here is an example of one of the many line graphs I created (due to realizing it is the best data visualization for this type of data):

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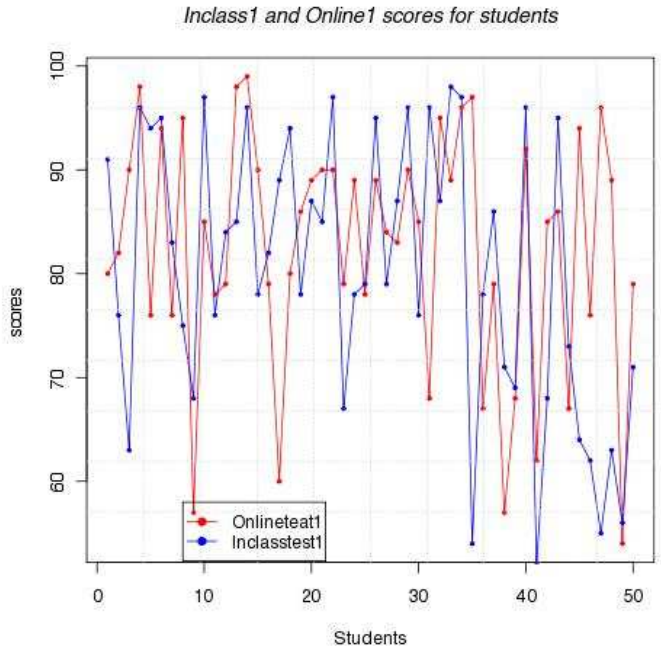
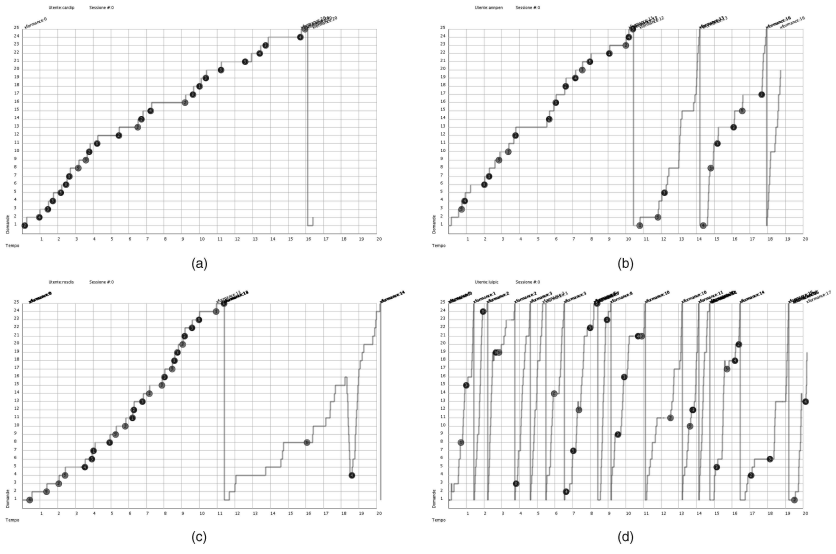
Table 8
Scatter plot of in-class and online student scores



Comparing types of similar data visualization techniques

Although visually displaying two different types of data, line graphs are the most effective and best forms of data visualization for showing these kinds of patterns. In addition to using the standard line graph (as shown above), a step-ladder visualization emphasizes different phases. These are shown in the first three (a-c):

Table 9
Sample line graphs



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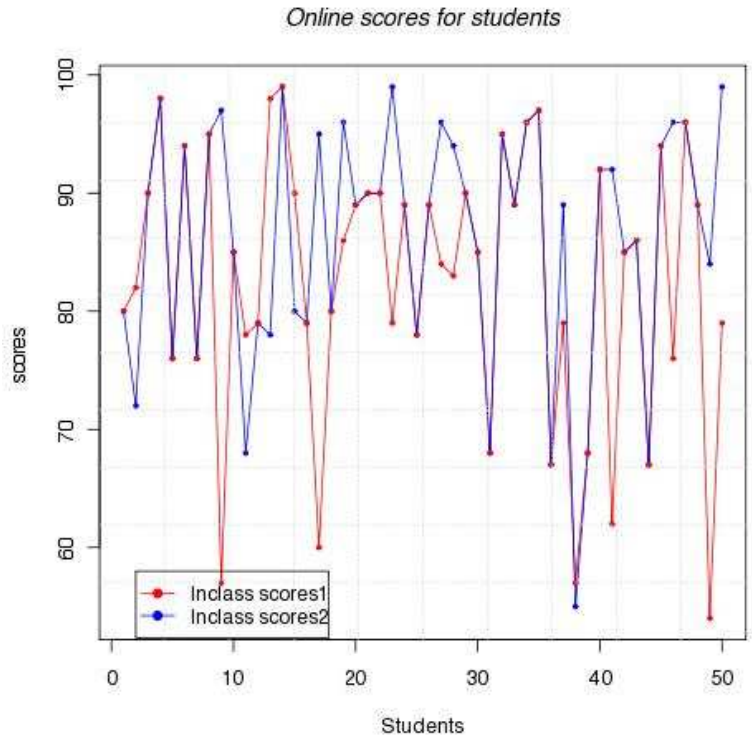
The last visualization (d) shows that the general pattern is a-typical. This type of visualization is, thus, the best way to illustrate numeric data such as test scores. In the next, section, I will describe why and how I specifically analyzed data based on this particular type of line graph.

Analyzing the Data

As mentioned, I found that the best type of data visualization for analyzing test scores is a line graph. As a result, I created a line graph to display students' performance after taking each test (in-class as well as online). The next step entailed comparing the online exam scores to the in-class scores. Finally, I compared two of each and analyzed the outcomes considering order (which test was taken first) as a factor.

First Exam Scores:

Table 10
Scatter plot for online student scores



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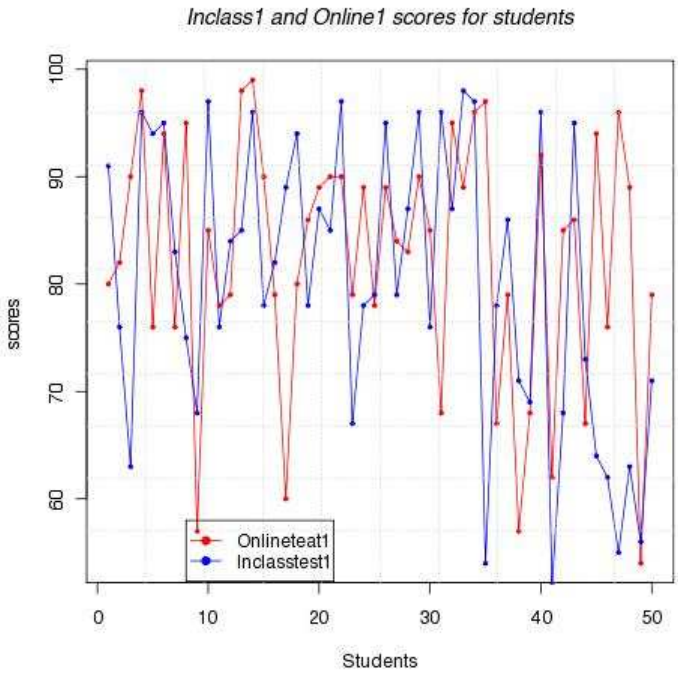
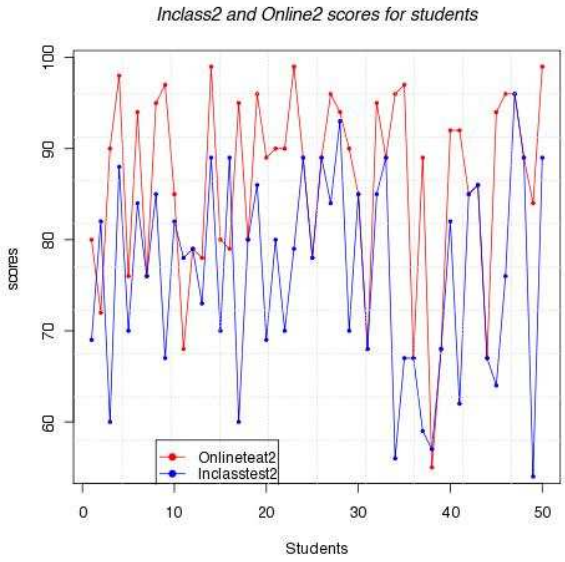
First Comparison:

Table 11
First scatter plot for in-class and online student scores



Second Comparison:

Table 12
Second scatter plot for in-class and online student scores



RESULTS AND DISCUSSION: USING TECHNOLOGY IN THE CLASSROOM

The first data visualization for the first exam scores shows that most students scored consistently except for the couple that did well on the first test and subsequently, 'took it for granted' and scored relatively much worse on the second exam.

The first comparison between in-class and online exam scores shows that students scored consistently except for the couple who did much better/worse on either the online or in-class exam (clear example demonstrated through the last couple scores at the end who scored much better on the online test).

The last comparison shows students generally scoring much higher on the online exams. This seems to demonstrate that the more online tests students take, the higher they score. This could possibly be explained by observing the transitions students experience from taking in-class exams to taking exams online.

Looking at the first data visualization that shows the first comparison for in-class to online exams, one can easily see that a couple students scored exponentially higher (by 35 %) on the online tests, which debunks the theory of transition. So what could possibly be the reason for these 'outliers' that don't follow the pattern?

One possible factor is cheating. Some possible ways of detecting cheating include following eye movement through such patterns as mouse browsing. In the future, I would like to use data visualization to try to solve some of these questions and problems to improve assessment and make it as sound and fair as possible.

In general, not only are students scoring higher on online exams but they also seem to be more motivated to use this kind of technology. In the past, using computer technology in learning activities such as conducting online exams has been perceived as a trend whereby instructors felt ambivalent about using technology (namely computers) as a way of improving education (Bednarz, 1995). Presently, however as demonstrated through this study, students are just as motivated to learn and use technology as instructors. Prensky (2001) makes note of the generational gap between the student and the instructor, believing that even though many instructors were not born during this digital era, their position of being "Digital Immigrants" does not hinder them from using technology to their own advantages. For the generation of mostly students who were, in fact born in the digital era, Artvinli (2009) coins the term "Digital Inhabitants," students who are becoming experts on technological advances and are taking the transition of these improvements much easier.

Another factor to consider is the structure of the exams. The way questions are asked, both verbally and how they are presented on a test makes a difference in stimulating the students' thinking and the answers they choose (Pizzini, Shepardson, and Abell 1992; Wilen 2001; Vogler 2005)

CONCLUSION

Although there have been studies on how geography technologies such as geovisualization can be integrated into curriculum to the degree of creating a 'culture' that promotes instructors to use geography technologies in their lessons (Jenner, 2006), there have not been many studies on how they can use geography technologies namely geovisualization for their own pedagogic purposes. One question that I pose is whether geography technologies and data visualization in education are more useful as a tool for instructors or should they become a primary goal for both students and teachers, alike?

Chalmers (2006) does not believe that technologies such as geovisualization and GIS, are as beneficial for instructors as they are for students because of teachers' lack of time. To counter this argument, there are many examples of programs that adequately train instructors in using new technologies in a short amount of time

(Johansson, 2006; Kerski, 2003; McClurg & Buss, 2007; Mota et. al., 2006; Siegmund et. al., 2007). In general, there are more instances and a wider research literature that supports both instructors and students mutually benefiting in a learning-teaching process from geography technology (Aladag, 2007, Alibrandi, 2003, Alibrandi & Sarnoff 2006; Beishuizen, 2006; Demirci, 2004, 2006, 2007; Donert, 2006a, 2006b; Ida, 2006; Johansson, 2006; Kerski, 2000, 2003, Mark, Kay & Dan, 2003; Siegmund et. al., 2007). This is true to the degree of a "culture" being created around using geography technologies (namely GIS and geovisualization) so that instructors are developing new ways of integrating these technologies into their lessons (Jenner, 2006). Simultaneously, it benefits the students in that "it can be the means to professional development" (Artvinli, 2009, 11).

Data visualization in particular has been enhancing the human capability to detect patterns, arrangements, and relationships between data elements while exploring the data (Chun-houh et al, 2007). My experiments demonstrate how data visualization can not only contribute to noticing patterns and comparing methods, but how it can lead to generally improving teaching and assessment processes by analyzing different forms of data visualization. It demonstrates how some data visualization is better for showing some data and patterns than others, depending on the variables, purpose, and techniques used.

Besides using data visualization, other forms of assessing student learning patterns include student involvement through participatory methods. Scholars such as Logan support student surveys that allow them to evaluate the online system Instructors use. These surveys would include questions such as "to what extent does the site's design reinforce or undermine the central message?" (Logan, 5, 2007). Furthermore, questions about the 'user friendliness' of the site could also be incorporated into survey such as "how easy is the site to use?" (Smith, 2001, 1). Therefore, students would evaluate "the site's navigation scheme." However, due to students' different background experiences with technology and personal biases, the surveys would not demonstrate an objective reflection of students' performance on online versus in-class exams. Although studies such as the one by Wilbanks (2004) have considered both the geographical dimensions of technology in education and society at large and the technological dimensions of education and geography in society, my own study is original in that it examines a phenomena involving technology (online exams) by using technology (data visualization).

Other arguments about the general use of technology in classrooms by students as well as by instructors include the concept of 'isolation'. This is a notion discussed by David Higgitt (2010) in that the use of computers in classrooms isolates the students from each other and isolates the students from the instructor. However, Logan (2007, 1) states that "Ideally the computer is an object around which social interaction in the classroom occurs, rather than a technology that serves to isolate students from each other and their teachers." One solution may be hybrid courses. Others recommend using computers and online sources in classrooms "in conjunction with non-Web resources including atlases, books, newspaper articles, and evidence collected by students themselves in the field" (Logan et al, 2010, 5) while others perceive the use of technology as an ethical issue in which "Some have called for ethics instruction to counter undesired uses of the technology" (Wetherholt, 2010, 1).

As a result, there are pluses and minuses "of both real and virtual course[s]" (Colvard, 2006, 1) as well as the methods used to assess the effectiveness of the 'virtual' and 'non-virtual' component(s) of the class. I found that data visualization is an effective method to compare student performance and detect patterns. There are ways of finding the pattern you want to see or the information that you would like to display (i.e. the 'outlier') depending on the type of data visualization one uses, in turn 'personalizing' the process. In my particular study, I found the scatter plot to be the most effective to show the transition of students switching from taking in-class to online exams and the results of those exams. With the constant development of new programs and enhanced visual techniques, there will be an increasing amount of freedom to choose what form of visualization works best for one's own data and study.

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